# MOULT CYCLE IN THE SWIMMING CRAB *PORTUNUS SPINIMANUS* (BRACHYURA, PORTUNIDAE) FROM UBATUBA, SÃO PAULO, BRAZIL

**Sandro Santos**[1]


### ABSTRACT

The molt cycle of *Portunus spinimanus* Latreille, 1819, and its association with temperature and sexual maturity is studied. Monthly samples over a two years period were carried out with the aid of a fishing boat equipped with "otter-trawl" nets in the Ubatuba region, São Paulo, Brazil. A total of 1798 specimens were captured and their molting stage and sexual maturity status were recorded. A positive correlation was obtained between temperature and proportion of molting females during the 1st year and in the males, no associations were observed. During almost all sampling period, the major part of the population was composed by intermolt adult crabs with developed gonads. This fact suggests that mating activity in the species is not high, since portunid females only mate during recently molted stages.


KEYWORDS. Moult cycle, *Portunus spinimanus*, Portunidae, Ubatuba, Brazil.

## INTRODUCTION

SATHER (1966) correlated the molt cycle stages length with environmental factors such as salinity, temperature, calcium contents and inorganic dissolved phosphates in the swimming crab *Podophtalmus vigil* Fabricius (Decapoda, Portunidae), and found that only temperature shows a moderate correlation. None of the other factors showed a similar influence. Despite being somehow related to molting, they do not act as trigger mechanisms.

The seasonal nature of molting activity can be a function of the availability of favorable conditions, such as appropriate temperature and food abundance. Higher temperatures may increase the metabolic rate and, thus, accelerate the molt cycle. Another factor influencing this seasonality is photoperiod (AIKEN, 1969).

Besides the environmental factors, the molt cycle in crustaceans is directly affected by gonadal development. Mating in brachyuran males occur during the intermolt condition. This characteristic must not be regarded as an obstacle, since these organisms pass the most part of the time in this molt phase (HARTNOLL, 1969). In females of a great number of species mating occurs when the exoskeleton is still soft, however this is not the general rule.

1. Departamento de Biologia, Centro de Ciências Naturais e Exatas, Universidade Federal de Santa Maria, RS 509, Km 09, Santa Maria, RS, CEP 97105-900, Brasil.

According to HARTNOLL (1969), the majid mating systems involve both soft and hard shelled females. In the Xanthidae, there are also records of hard shelled mating females, as is the case of *Lophopanopeus bellus* diegensis Rathbun and *Paraxanthias taylori* (Stimpson) (KNUDSEN, 1960), *Neopanope sayi* (Smith) (SWARTZ, 1976,1978) and *Panopeus rugosus* A. M. Edwards (PINHEIRO, 1993). In fact, many crustaceans exhibit a close relationship between the molt cycle and reproduction, especially in the case of adult females, in which the ovarian development is dependent upon organic resources (ADIYODI & ADIYODI, 1970).

This study relates the molt cycle of *Portunus spinimanus* Latreille, 1819, as a function of temperature and its association with the gonadal development.

## MATERIAL AND METHODS

Monthly otter-trawl samples of *Portunus spinimanus* were realized in the Ubatuba region, São Paulo, Brazil, from May 1992 to April 1994.

The main molt cycle phases are the post-molt, the intermolt, and the pre-molt. DRACH (1939,1967) proposed a more detailed subdivision, in which the symbols A1, A2, B1, B2, C1, C2, C3 correspond to post-molt substages; C4 to the intermolt stage; D0, D1, D2, D3, D4, to the pre-molt sub-stages and, finally, the stage E that corresponds to ecdysis. This subdivision has been widely adopted with some adaptation. Here molt cycle stages were assigned basically according to SKINNER (1962, 1985); modifications of this method are indicated: stage A, initial post-molt: exoskeleton very soft, decrease of size in epidermic cells (modified) the crab looks shriveled; stage B, advanced post-molt: the exoskeleton begins to harden and seems like parchment, but is still easily perforated by a needle, it corresponds to stages B, C1, C2 and C3 (modified); stage C, intermolt: the carapace is totally calcified with maximum consistency, it corresponds to stage C4 (modified), at this stage the organic stock allocation begins; stage D, pre-molt: the new exoskeleton can be found under the old cast and the ecdysial line can be observed in the pterygostomian region and in the inner side of the chelipeds meri, this stage corresponds to D0, D1, D2, D3 and D4 (modified); stage E, ecdysis: the crab is emerging from the old exoskeleton.

The data were grouped in two major categories: first, crabs in molting activity (CMA), including stages A, B, D and E, and second, intermolt crabs (InC), including only the stage C. The occurrence of swimming crabs in each category was monthly examined, along the two years. sampling period. The GOODMAN (1964,1965) test for contrasts, among and within multinomial populations (in this case binomials), was used to compare the ratios obtained.

Water temperature data were obtained from the Instituto Oceanográfico, Uiversidade de São Paulo, Base Norte, Ubatuba, São Paulo, Brazil. The correlation between molt cycle and temperature (Pearson's linear correlation) was analyzed by means of fitting linear or linearized functions according to DRAPER & SMITH (1966).

Males with inverted-T shaped abdomen, visible gonads after disseccion and whitish vas deferens and females with subcircular abdomen, visible yellow or orange gonads and volumetrical ratio between gonads and hepatopancreas higher than 1/8, were considered mature individuals. The GOODMAN (1964, 1965) statistical test was employed also to analyze the relationship between the molt and reproductive cycles. In the analysis, frequency of mature or immature individuals and frequency of CMA or InC individuals were used.

Voucher specimens are deposited in Laboratório de Crustáceos, Departamento de Biologia, Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, Brazil.

## RESULTS

Were analyzed 1,733 crabs captured in this study (figs. 1,2). During the two years study period no within month significant differences were recorded in the males categories CMA and InC (tab. I ). However, within group analyses in both categories reveals that males in intermolt outnumbered males in molt activity in May, July, August, November and March during the 1st year, while the opposite was verified in January. No differences were observed in June, September, October, December, February and April.

During the 2nd year the proportion of intermolt individuals was always higher. In spite of not being observed statistical differences, higher proportions of molting males were recorded in June, August and February.

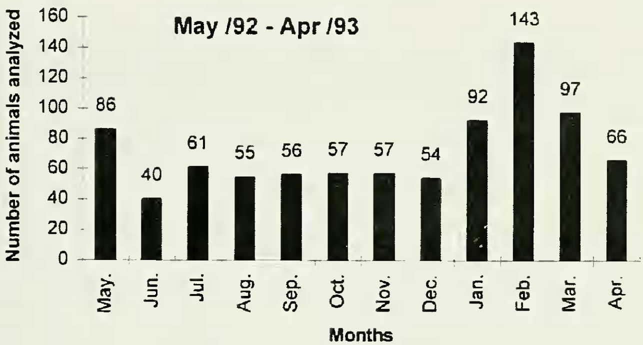
In females, within month analysis in the 1st year revealed that significant higher CMA proportions were those obtained in December, January, February and March, while the lower ones were recorded in July, August and November (tab. II). In InC, the opposite was found.

Within group analysis did not evidence significant differences in December, January and March. In the other months, InC proportions were always superior. During the 2nd year no statistical differences were registered in neither within month nor within group analyses. In all months, the proportion of InC was always higher.

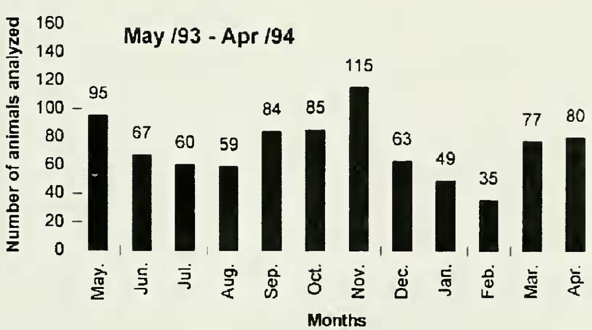
In the 1st studied period no correlation was found between the male molt cycle and temperature, while in females a significant positive association was found. During the second year, such correlations were not recorded (tab. III).

In both years, the major part of mature crabs collected were InC individuals. In immature CMA outnumbered immature InC specimens (tab. IV).

1




2




Figs. 1, 2. Number of *Portunus spinimanus* analyzed in each month of study: 1, first year; 2, second year.

Table I. Results of Goodman test: Proportion of males of *Portunus spinimanus* in molting activity (CMA) and in the intermolt condition (InC), from May/92 - Apr/93 (year 1) and May/93 - Apr/94 (year 2) in Ubatuba, São Paulo, Brazil. Small letters indicate within group analysis and capitals indicate within month analysis.

| | Year 1 | | Year 2 | |
|---|---|---|---|---|
| Month | CMA | InC | CMA | InC |
| May | 0.238 a A | 0.762 a B | 0.146 a A | 0.854 a B |
| June | 0.692 a A | 0.308 a A | 0.348 a A | 0.652 a B |
| July | 0.300 a A | 0.700 a B | 0.136 a A | 0.864 a B |
| August | 0.250 a A | 0.750 a B | 0.313 a A | 0.687 a B |
| September | 0.333 a A | 0.667 a A | 0.217 a A | 0.783 a B |
| October | 0.438 a A | 0.562 a A | 0.150 a A | 0.850 a B |
| November | 0.182 a A | 0.818 a B | 0.167 a A | 0.833 a B |
| December | 0.519 a A | 0.481 a A | 0.167 a A | 0.833 a B |
| January | 0.682 a B | 0.318 a A | 0.063 a A | 0.937 a B |
| February | 0.518 a A | 0.482 a A | 0.250 a A | 0.750 a B |
| March | 0.341 a A | 0.659 a B | 0.042 a A | 0.958 a B |
| April | 0.370 a A | 0.630 a A | 0.200 a A | 0.800 a B |

Table II. Results of Goodman test: Proportion of females of *Portunus spinimanus* in molting activity (CMA) and in the intermolt condition (InC), from May/92 - Apr/93 (year 1) and May/93 - Apr/94 (year 2) in Ubatuba, São Paulo, Brazil. Small letters indicate within group analysis and capitals indicate within month analysis.

| | Year1 | | Year 2 | |
|---|---|---|---|---|
| Month | CMA | InC | CMA | InC |
| May | 0.185 ab A | 0.815 ab B | 0.130 a A | 0.870 a B |
| June | 0.259 ab A | 0.741 ab B | 0.205 a A | 0.795 a B |
| July | 0.098 a A | 0.902 b B | 0.184 a A | 0.816 a B |
| August | 0.106 a A | 0.894 b B | 0.256 a A | 0.744 a B |
| September | 0.184 ab A | 0.816 ab B | 0.230 a A | 0.770 a B |
| October | 0.317 ab A | 0.683 ab B | 0.154 a A | 0.846 a B |
| November | 0.174 a A | 0.826 b B | 0.271 a A | 0.729 a B |
| December | 0.444 b A | 0.556 a A | 0.242 a A | 0.758 a B |
| January | 0.457 b A | 0.543 a A | 0.212 a A | 0.758 a B |
| February | 0.367 b A | 0.633 a B | 0.222 a A | 0.788 a B |
| March | 0.415 b A | 0.585 a A | 0.094 a A | 0.906 a B |
| April | 0.231 ab A | 0.769 ab B | 0.123 a A | 0.877 a B |

Table III. Pearson's linear correlation coefficients for the relationship between temperature (T °C) and molting activity (CMA) crabs of *Portunus spinimanus* (males and females). Level of significance is expressed between brackets.

| Correlation | Year 1 | Year 2 |
|---|---|---|
| T °C x female CMA | 0.75 ($p < 0.01$) | -0.36 ($p > 0.05$) |
| T °C x male CMA | 0.45 ($p > 0.05$) | -0.46 ($p > 0.05$) |

Table IV. Proportions of mature and immature crabs of *Portunus spinimanus* in each molting status during two years. Small letters indicate within gonadal group analysis, capitals indicate within molt group analysis.

| | Males | | Females | |
|---|---|---|---|---|
| | Mature | Immature | Mature | Immature |
| year 1(May92-Apr/93) | | | | |
| Molt activity (CMA) | 0.226 a A | 0.774 b B | 0.623 a B | 0.377 b A |
| Intermolt (InC) | 0.568 b A | 0.432 a A | 0.840 b B | 0.160 a A |
| Year2 (May/93-Apr/94) | | | | |
| Molt activity (CMA) | 0.725 a B | 0.275 b A | 0.851 a B | 0.149 b A |
| Intermolt (InC) | 0.880 b B | 0.120 a A | 0.981 b B | 0.019 a A |

In the within molting condition analysis, in all cases but males during the 1$^{st}$ year, in which CMA specimens were predominantly immature, and no difference was recorded regarding InC individuals, mature crabs outnumbered immature in both CMA and InC molting condition groups.

## DISCUSSION

Variability in intermolt period duration exists within different species and is also present in intraspecific comparisons when different development phases are analyzed. This variability occurs mainly because of the integument calcification level (CONAN, 1985). In a general sense, brachyuran crabs are provided with a relatively high calcified exoskeleton, depending on the development phase of these organisms.

The intermolt period of juvenile crabs is shorter than in adults, therefore, the relative chances of sampling CMA juveniles are higher. Thus, during this phase the species follows diecdysis, i.e. fast growth with short intermolt intervals. In the other hand, the great part of adults were InC individuals entering an anecdysis cycle, which can be regulated in a seasonal basis. In some species anecdysis leads to a terminal molt (HARTNOLL, 1969; CONAN, 1985). This is not the case of *Portunus spinimanus*, confirming the observed pattern in *P. sanguinolentus* (Herbst) (RYAN, 1967). In this study, females larger than 60 mm with subcircular abdomen, evidencing a stage of morphological maturity (SANTOS **et al.**, 1995), were observed in the premolt stage. This fact evidences the lack of terminal moult in this species.

The positive correlation found between sea water temperature and CMA females in the 1$^{st}$ year may be related to a seasonal molting activity. During this same year, the higher proportion of CMA males was recorded in January when mean sea water temperature was 27.5 °C.

According to SATHER (1966), even growing continuously throughout the year, higher temperatures increase molting frequency in *Podophtalmus vigil* (Fabricius). Other species, such as *Carcinus maenas* (L.) (CARLISLE, 1954), present higher molting frequencies during winter.

CMA rates were frequently higher 10%, but variable during the 1$^{st}$ year. Molt seasonality is still not well understood. It has been pointed out that temperature, temperature changes or even a phylogenetical constraint are the ruling factors of molt activity patterns (CONAN, 1985). The absence of significant correlations during the 2$^{nd}$

year for both males and females suggests that temperature is not the only factor affecting the molt cycle of *P. spinimanus*. It is possible that favorable metabolic conditions for molting occur within a given temperature range. In spite of the considerable temperature fluctuation observed during the two-year period it is likely that permissible molting temperature conditions are always met in this local. It must be considered that sampling was conducted in a tropical region.

During mating, male brachyuran crabs are generally in intermolt while regarding females there are species in which mating occurs when crabs are in intermolt, recently molted or even species in which females can mate in both conditions (HARTNOLL, 1969). Female molting stage at mating depends on the adaptive reproductive strategy of this animals. Probably, the gonopod intromission into female vulvae is facilitated when females are in the recently molted stage. Mating in the intertidal, as verified in *Panopeus rugosus*, should minimize predator exposure during this critical event (PINHEIRO, 1993).

Mature males in the intermolt condition, which are usually provided with well developed gonads, are available all over the year. Most part of females with developed gonads were InC, while immature specimens were in their major part CMA individuals. As far as a great part of female crabs showed required conditions to oviposition, i.e. hard exoskeleton and developed gonads, it is possible to assume that the availability and physiological condition of adults are not limiting factors for egg production in *P. spinimanus*. Nevertheless, due to the observed scarcity of molting females, mating events should be restricted events. This fact is probably offset by a continuous egg development, indicating that females can produce consecutive spawns in a single mating event.

The intermolt condition in brachyuran crabs represents more than 66% of the molt cycle duration, while the premolt stage corresponds to 25%. This fact allows the accomplishment of more than one reproductive cycle during the intermolt condition in these organisms.

In the present study mature CMA individuals were recorded in all molt activity stages, i.e. A, B, D and E. In brachyurans, somatic growth and reproduction are temporarily separated. According to SKINNER (1985), the energetic resources allocation for molting and development of limb buds occur between the end of stage C and the beginning of stage D. This should be also the case in *P. spinimanus*. Then, during stages A and B, the gonadal development begins. Most part of collected specimens recently molted were crabs of stages A and B. According to ADIYODI (1985), simultaneous growth and reproduction would require a very severe energy expenditure. Brachyuran crabs should have solved this problem by maintaining this processes as antagonic events.

**Acknowledgments**. To FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo), for the financial support (proc. nº 92/1941-5 and 94/4878-8), to Dr. Carlos Roberto Padovani for his help in statistical analysis.

## REFERENCES

Adiyodi, K. G. & Adiyodi, R. G. 1970. Endocrine control of reproduction in Decapod Crustacea **Biol. Rev.**, Cambridge, **45**:121-165.

Adiyodi, R. G. 1985. Reproduction and its control. **In**: Bliss, D. E. & Mantel, L. H. eds. **The biology of Crustacea**. Integument, pigments, and hormonal process. New York, Academic, v. 9 , 549p.

Aiken, D. E. 1969. Photoperiod, endocrinology and the crustacean molt cycle **Science**, Washington, **164**:149-155.

Carlisle, D. B. 1954. On the hormonal inhibition of moulting in decapod Crustacea **J. mar. biol. Ass. U.K.**, Cambridge, **32**:289-295.

Conan, G. Y. 1985. Periodicity and phasing of molting. **In:** WENNER, A. M. ed. **Factors in adult growth.** Boston, A. A. Balkeman. 349p.

Drach, P. 1939 Mue et cycle d'intermue chez les Crustacés Décapodes **Inst. Annls. Oceanogr.**, Monaco, **19**:193-391.

__. 1967. Sur la méthod de determination des stades d'intermue et son application générale aux crustacés. **Vie Milieu**, Paris, **18**(3A):595-610.

Draper, N. R. & Smith, H. 1966. **Aplied regression analysis**. New York, Wiley. 407p.

Goodman, L. A. 1964. Simultaneous confidence intervals for contrasts among multinomiae populations **Ann. math. Statist.**, Ann Arbor, **35**(2):716-725.

__. 1965. On simultaneous confidence intervals for multinomiae proportions. **Technometrics**, Washington, **7**(2):247-254.

Hartnoll, R. G. 1969. Mating in the Brachyura. **Crustaceana**, Leiden, **16**:161-181.

Knudsen, J. W. 1960. Reproduction, life history, and larval ecology of California Xanthidae, the pebble crabs. **Pacif. Science**, Honolulu, **14**:3-17.

Pinheiro, M. A. A. 1993. Comportamento copulatório de *Panopeus rugosus* A. M. Edwards, 1880 (Crustacea, Brachyura, Xanthidae) em cativeiro. **Biotemas**, Florianópolis, **6**(1):115-120.

Ryan, E. P. 1967. The morphometry of sexually mature instars of the blue crab *Portunus sanguinolentus* (Herbst) (Brachyura, Portunidae). **Proc. symp. Crust. Mar. biol. Ass. India**, Ernakulan, (2): 715 - 723.

Santos, S.; Negreiros-Fransozo, M. L. & Fransozo, A. 1995. Morphometric relationships and maturation in *Portunus spinimanus* Latreille, 1819 (Crustacea, Brachyura, Portunidae). **Revta bras. Biol.**, Rio de Janeiro, **55**(4): 545-553.

Sather, B. T. 1966. Observations on the molt cycle and growth of the crab, *Podophtalmus vigil* (Fabricius) (Decapoda, Portunidae). **Crustaceana**, Leiden, **11**(2):185-197.

Skinner, D. M. 1962. The structure and metabolism of a crustacean integumentary tissue during a molt cycle. **Biol. Bull.**, Woods Hole, **123**:635-647.

__. 1985. Interacting factors in the control of the crustacean molt cycle. **Am. Zool.,** Thousand, **25**:275-284.

Swartz, R. C. 1976. Agonistic and sexual behavior of the Xanthid crab, *Neopanope sayi*. **Chesapeake Sci.**, Solomons, **17**(1):24-34.

__. 1978. Reproduction and molt cycles in the xanthid crab *Neopanope sayi* (Smith, 1869). **Crustaceana**, Leiden, **34**(1):15-32.

Recebido em 27.02.1998; aceito em 24.06.1998